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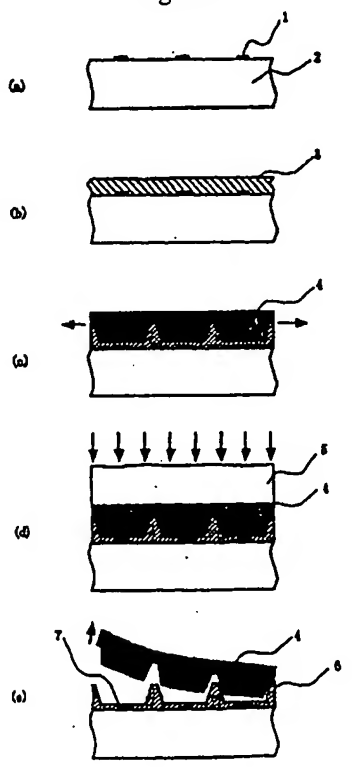
(54) **[Title of the invention]** Gas discharge type flat panel display devise and its production method

57) **[Summary]**
[Objective] The objective of this invention is to provide a transfer forming method for separation wall which is able to perform secure mold release.
[Means to solve] In order to accomplish above described objective, in production method of separation walls for gas discharge type flat panel display devices wherein the shape of separation walls is formed on a back plate by pressing a forming mold having a reverse pattern of specific shape of separation walls to the separation wall paste, this invention comprises; a process to coat the separation wall paste in specific thickness in film shape on the electrode forming surface on back plate where electrodes have been formed on the surface,

Figure 1



a process to harden in a condition that the forming mold having a specific shape is pressed against the separation wall paste that has been coated in film shape, until the strength of the separation wall paste becomes stronger than the contact strength of the separation wall paste with said forming mold, and a process to release said forming mold from the hardened separation wall paste.

[Patent claims]

[Claim 1] In production method of separation walls for gas discharge type flat panel display devices wherein the shape of separation walls is formed on a back plate by pressing a forming mold having a reverse pattern of specific shape of separation walls to the separation wall paste, a production method of gas discharge type flat panel display device that is characterized by comprising;

a process to coat the separation wall paste in specific thickness in film shape on the electrode forming surface on back plate where electrodes have been formed on the surface,

a process to harden in a condition that the forming mold having a specific shape is pressed against the separation wall paste that has been coated in film shape, until the strength of the separation wall paste becomes stronger than the contact strength of the separation wall paste with said forming mold, and

a process to release said forming mold from the hardened separation wall paste.

[Claim 2] A production method of gas discharge type flat panel display device that is described in Claim 1 and characterized by using separation wall paste that contains ultraviolet curing type organic binder but does not contain volatile solvent, and back plate that transmits ultraviolet light, and by hardening said separation wall paste through the back plate by irradiating ultraviolet light on the surface of the back plate where the separation wall paste is not coated.

[Claim 3] A production method of gas discharge type flat panel display device that is described in Claim 1 and characterized by using separation wall paste that contains thermally curing type organic binder but does not contain volatile solvent, and by thermally hardening said separation wall paste through the back plate by irradiating far infrared light on the surface of the back plate where the separation wall paste is not coated.

[Claim 4] A production method of gas discharge type flat panel display device that is described in Claim 1 and characterized by using thin plate elastic forming mold with cushion material as said forming mold.

[Claim 5] A production method of gas discharge type flat panel display device that is described in Claim 1 and characterized by passing; said back plate that is coated with the separation wall forming paste while being sandwiched between top and bottom plates of an open-and-close type transportation and forming jig that has an top plate having a thin plate elastic forming mold that has a specific separation wall shape on its one surface and has a bottom plate having a positioning and fixing mechanism of the back plate on its opposing surface to the forming mold, and one end of each is connected with a joint that is able to rotate and move in up and down; throughout the hardening process and mold releasing process.

[Claim 6] A gas discharge type flat panel display device that is characterized by being formed with,

a process to coat the separation wall paste on the electrode forming surface on back plate where electrodes have been formed on the surface,

a process to harden while in a condition that the forming mold having a specific shape is pressed against the separation wall paste that has been coated on the back plate until the strength of said separation wall paste becomes stronger than the contact strength of the separation wall paste with

the forming mold, and
a process to release said forming mold from the hardened separation wall paste,
and said separation wall paste after hardening covers the electrodes that are formed on said back plate in thin layer within a region between the separation ribs after forming.

[Detail description of the invention]

[0001]

[Technology field that this invention belongs to] This invention concerns gas discharge type plat panel display devices, namely so-called plasma display panels (PDP) and their production method, and especially it concerns production method of the separation walls that are used for the gas discharge type flat panel display devices and back plates that are mounted with them.

[0002]

[Prior technology] As the production method of separation walls for PDP, the sand blast method has been generally accepted which is disclosed in patent publication notice of patent Publication No. Hei 7-45192.

[0003] As shown in Figure 6 of its outline, this method is a method for forming the separation wall ribs 26 by, (a) on the back plate 22 that is formed with electrodes 21, (b) piling up glass paste 23 up to necessary thickness by repeating printing and drying with silk screen printing method for example, then (c) applying photosensitive dry film resist on its surface and forming the mask 24 of dry film resist with pattering of photo-lithography method. Then, (d) by irradiating abrasive material 25 on the surface by sand blast method to remove dry glass paste where the dry film resist does not exist, then (e) removing the dry film and baking.

[0004] On the other hand, there is a method to form the separation walls with mold forming which has been drawing attention in recent years.

[0005] Figure 7 is a technology that transfer forms the separation wall pattern by pressing forming pattern to glass paste, and it has been disclosed in the public notice of Patent Publication Hei 8-273538. In the drawing, electrodes are omitted for simplification. This is a method for forming the separation wall ribs 26 that at first, (a) glass paste 22 is coated on a back plate 22, then (b) shape of the mold is transferred by pressing the negative shape mold 31 of the separation wall ribs, that is formed with ionized* radiation curing type polymer material on the surface of film substrate 30 having elasticity, to the glass paste 23, and after this, (c) the mold 31 is released while soft.

** Translator's note: This "ionized" shall be a typographical mistake of "electron", Japanese pronunciations of "ionized" is "denri" and "electron" is "denshi", respectively and very similar.*

[0006] Further, Figure 8 is a technology to form the separation wall ribs 26, that pre-forms the shape of ribs by burying the glass paste 23 in the grooves of burying mold 40 having a reverse contour pattern of the separation wall, then bond to the back plate 22 and release the mold 40, which is disclosed in the public notice of Patent Publication Hei 9-134676.

[0007]

[Problems that the invention is to solve] Although the sand blasting method has an advantage that both the reproduction capability of shape and the capability of minute shaping are relatively good, there is a problem that the usage efficiency of separation wall material is extremely poor and cost is high. Namely, PDP is to display colors by exciting fluorescent materials using ultraviolet light that is generated by electric discharge by generating three colors of red (R), green (G) and blue (B). The separation wall separates the discharge region within a

plane so that these three colors of RGB would not interfere each other, and at the same time it is a separation wall for defining the distance between the front panel and back panel and the volume of discharging space. Accordingly, because of the necessity of expanding the light emitting area by making the area that is coated with fluorescent materials, the width of the separation wall, namely the width of ribs is designed as narrow as possible. Namely, most of the material other than the narrow separation wall ribs is removed with the sandblast. Although it depends on panel specifications, normally 50 to 75 % is disposed as process waste along with the grinding mineral, therefore, material yield is very poor. Further, because there is a need to sinter the separation wall material at a temperature as low as possible due to the limitations by structure and production process, inorganic powder material having lead glass powder that has low melting point has been used as its main ingredient. Therefore, if PDP in 55 to 60 inch class is produced 20,000 to 30,000 per month, for example, several tons to nearly ten tons of industrial waste is generated every month, which has a serious problem from the standpoint of environmental control.

[0008] In order to solve the above described problem, technologies that form the separation walls with a molding tool using minimum amount of material has been recently considered. The method that has been disclosed in said public notice of Patent Publication No. Hei 8-27353 is one of them and in order to make mold release easy and to make forming of the molding tool itself easy, it is to form a mold having a reverse pattern of the separation wall ribs on a polymer film using an ionized* radiation cure type polymer, transfer its profile by pressing it to glass paste, then release from the mold while the separation wall paste is still soft. Because the glass paste material generally contain inorganic materials such as ceramics other than the glass powder, this type of resin mold has short life and cost is high. Further, there is a problem that dimensional preciseness of finished separation wall is not good because polymer material has greater deformation due to heat or load. Furthermore, because ribs normally have 2 to 3 times in height over width, cross sectional area of a rib is much smaller than the side wall surface area of a separation wall rib that contacts the mold, therefore, it is obvious that it is not able to prevent the tearing of ribs at the connecting point with the back plate or in the middle of the height of the ribs, even if contact area is reduced by smoothening the surface of mold that contacts with the paste up to mirror surface and sufficient amount of releasing agent is used. Of course, sufficient cleaning in the grooves of mold is necessary.

** Translator's note: This "ionized" shall be a mistake of "electron" because Japanese pronunciation of them are "denri" and "denshi" respectively and they are easy to mix up in typing.*

[0009] Then, with the method that is disclosed in Paten Publication Hei 9-134676, the surface of rib material that is filled in the grooves becomes lower then the mold surface except for the grooves because the separation wall material shrinks in volume when it dries, therefore, it is practically impossible to bond all the separation wall ribs to the backside substrate even when the backside plate is mounted on the rib material tat is buried in the grooves. Further, even if they were well bonded, it is extremely difficult to release from the mold so that the multiple minute ribs, that has been buried and formed in a specific molding tool, can be all bonded to the back plate side in perfect shape, by the same reason that is described above.

[0010] Further, cycle time is reduced by the products with many heat treatment processes in production process like PDP by using such as a continuous oven to treat multiple units at the same time, however, above described 2 methods are not able to handle multiple numbers of forming process at the same time, and in order to reduce the cycle time, there is a need of such as

preparing multiple number of special forming equipment.

[0011] Considering problems of previous technologies as described above, the primary objective of this invention is to provide a method for transfer forming of separation walls which is able to have secure mold release.

[0012] The secondary objective of this invention is to provide uniform and highly precise transfer forming method of separation walls without requiring special forming equipment.

[0013] Further, the tertiary objective of this invention is to provide a shape of separation wall that is excellent in releasing property.

[0014]

[Means to solve the problems] In order to accomplish above described objective, in production method of separation walls for gas discharge type flat panel display devices wherein the shape of separation walls is formed on a back plate by pressing a forming mold having a reverse pattern of specific shape of separation walls to the separation wall paste, this invention comprises; a process to coat the separation wall paste in specific thickness in film shape on the electrode forming surface on back plate where electrodes have been formed on the surface, a process to harden in a condition that the forming mold having a specific shape is pressed against the separation wall paste that has been coated in film shape until the strength of the separation wall paste becomes stronger than the contact strength of the separation wall paste with said forming mold, and a process to release said forming mold from the hardened separation wall paste.

[0015] Further, it is to use separation wall paste that contains ultraviolet curing type organic binder but does not contain volatile solvent and back plate that transmits ultraviolet light, and to harden said separation wall paste through the back plate by irradiating ultraviolet light on the surface of the back plate where the separation wall paste is not coated.

[0016] Further, it is to use separation wall paste that contains thermally curing type organic binder but does not contain volatile solvent, and to thermally harden said separation wall paste through the back plate by irradiating far infrared light on the surface of the back plate where the separation wall paste is not coated.

[0017] Further, it is to use thin plate elastic forming mold with cushion material as said forming mold.

[0018] Further, it is to pass said back plate that is coated with the separation wall forming paste while being sandwiched between top and bottom plates of an open-and-close type transportation and forming jig that has an top plate having a thin plate elastic forming mold that has a specific separation wall shape on its one surface and has a bottom plate having a positioning and fixing mechanism of the back plate on its opposing surface to the forming mold, and one end of each is connected with a joint that is able to rotate and move in up and down; throughout the hardening process and mold releasing process.

[0019] Further, it forms with a process to coat the separation wall paste on the electrode forming surface on back plate where electrodes have been formed on the surface, a process to harden while in a condition that the forming mold having a specific shape is pressed against the separation wall paste that has been coated on the back plate until the strength of said separation wall paste becomes stronger than the contact strength of the separation wall paste with the forming mold, and a process to release said forming mold from the hardened separation wall paste; and said separation wall paste after hardening covers the electrodes that are formed on said back plate in thin layer within a region between the separation ribs after forming.

[0020] Figure 1 is an drawing that shows these forming processes in detail. In the drawing, 1 means electrode, 2 means back plate, 3 means separation wall paste, 4 means thin plate elastic

mold, 5 means cushion material, 6 means separation wall rib, and 7 means bottom film, respectively.

[0021] Its forming method is as follows.

[0022] At first, (a) on the surface formed with electrodes on the back plate 2 which is formed with electrodes 1 ahead of time, (b) separation wall paste 3 is coated which is thermally curable or UV light curable and does not contain solvent.

[0023] Then, (c) the air between the mold 4 and the separation wall material 3 is removed by de-aerating while pressing a thin plate elastic mold 4 having a specific shape, and contact is improved.

[0024] After that, (d) by hardening the separation wall material 3 with heat or irradiation of ultraviolet light while pressing the mold 4 through the cushion material 5 against the separation wall material at specific pressure, the formed separation walls are adhered to the back plate to be unified and sufficient strength that withstands the releasing force. By this, secure molding of separation wall that do not have defects such as bubbles with good height preciseness is enabled.

[0025] Then, (e) the separation walls 6 is formed by releasing the thin plate elastic forming mold 4 from one end while lightly bending it with the cushion material 5 removed. At this time, continuously connected separation walls are formed by controlling the pressure applied to the cushion material 5 so that appropriate thickness of bottom film 7 is formed between the separation wall ribs, and adhered area of the hardened ribs to the back plate is increased, which prevents separation of back plate from the formed ribs due to the mold releasing force. Further, because the rib material itself has been hardened and strength has been increased, breakage of the ribs at the middle of their height would not occur. With this, it is able to accomplish the primary and tertiary objectives.

[0026] Then, although it is not shown in the drawing, open-close type transportation and forming jig, that comprises two pieces of plates - a top plate having an elastic forming mold that has a specific shape of separation wall on one surface, and a bottom plate having a mechanism to fix a back plate on the surface that opposes this forming mold - is prepared. Then, a back plate, that has been coated ahead of the time with thermal curing or ultraviolet light curing type separation wall paste containing no solvent in the surface formed with electrodes, is mounted on the back plate fixing surface of this transportation forming jig, positioned and fixed, then by closing this top plate, *the thin plate elastic forming mold is transferred on the separation wall paste that has been coated on the surface of the back plate. By fixing in this condition, passing through de-aeration process and curing process, and then opening the top and bottom plate of the forming jig, a back plate having separation walls is produced. The second objective is able to be accomplished with this.

** Translator's note: Words "shape of" may be missing in original Japanese.*

[0027]

[Form of embodiment of the invention] In the following embodiment examples of this invention is explained by using drawings. Where, dimensions of such as mold grooves and separation wall ribs in the following all embodiment examples are displayed larger relative to the substrate and much less in number of them, due to the reasons of explanation and making drawings, in all of following embodiment examples.

[0028] <<Example 1>> Figure 2 is a production process drawing showing an embodiment example of this invention, and it is an example of forming stripe separation wall ribs having trapezoid shape cross section using separation wall paste that contains thermally curable organic binder material.

[0029] In the drawing, 8 means top plate, 9 means substrate positioning and fixing mechanism, 10 means bottom plate, 11 means hinge, 12 means substrate transport molding jig, 13 means de-aeration chamber, 14 means pressure force, and 15 means furnace, respectively.

[0030] At first, (a) a film of the separation wall paste 3 is formed on the electrode foaming surface of the back plate 2 that has been formed with the electrodes 1. Then, the substrate transport jig 12 is prepared which comprises top plate 8 wherein the thin plate elastic mold 4 is fixed with the cushion material 5 between them and the bottom plate 10 having the substrate positioning and fixing mechanism, and one end of each is connected with a hinge 11 that allows rotation and movement in vertical direction, and (b) said back plate is positioned and fixed on the bottom plate 10 of this jig. Then, (c) top plate 8 is lowered to lightly press the thin plate elastic mold 4 onto the separation wall paste 3, and while keeping this condition, entire jig 12 is placed in the de-aeration chamber 13 to remove the entrapped air at the boundary between the mold 4 and the separation wall paste 3 by exhausting the air. After this, (d) it is heated in the furnace 15 while applying the pressure force 14 on the top plate. The pressure force at this moment does not have to be very strong and it will be sufficient if surface pressure is about 100 g/cm^2 at most. Further, even if there is a warp in the back plate 2 it is able to uniformly pressurize following the warp by inserting the cushion material 5 between the thin plate elastic mold 4 and top plate 8 as this embodiment example. Also, this embodiment example shows an example of hardening by placing the separation wall material in an furnace, however, if light transmission property is given to the bottom plate by making the bottom plate in grid shape or making it with transparent material, for example, heating with such as far infrared heater through the back plate is possible therefore, there is no need to place in a furnace. After the hardening of the separation wall material is thus completed, (e) mold release is done by opening of the top plate 8 of the jig 12. Because the jig which is fixed at one end with the hinge 11 in free of rotation at this moment, the releasing of mold progresses from one end of molded surface in sequence, which enable to release from the mold at less force compared with releasing the entire surface at one time, and able to prevent breakage of the separation walls and de-lamination from the back plate. Where, it is displayed in the drawing that the releasing from the mold is done in the direction of the width of ribs in order to draw the condition of releasing from the mold for easy understanding, however, if considering the interference between the forming mold and ribs, it is more desirable to release from the mold in the longitudinal direction of the ribs. At last, (f) by removing the back plate from the bottom plate 10, a back plate is obtained that is formed with the separation wall ribs 6 on its surface.

[0031] As explained because this invention is a method to harden the separation wall paste while the forming mold is pressed against it until sufficient strength is obtained then to release from the mold, it is able to securely form the separation wall compared to the previous forming method which releases while it is soft, and there is no concern that a part of paste would remain in the forming mold. Further, by making it in a structure of a jig, it does not require special converting facility and is able to control facility cost low.

[0032] The second embodiment example of this invention is described in below.

[0033] Figure 3 is a drawing showing the second embodiment example of this invention, which is an example of forming the separation wall by using a separation wall paste containing organic binder of ultraviolet light curing type. In the drawing, 16 means ultraviolet light.

[0034] It is basically the same as the first embodiment example that cures with heat, however, it is a method that the bottom plate 10 is provided with openings or formed with a material that transmits light, and cures the separation wall material with light at (d) by irradiating ultraviolet

light through the back plate 2. The most significant characteristic of this method is that because it is light curing, therefore, it enables operation at room temperature, and accordingly there is no need for considering compensation of dimensional expansion due to increased temperature. Further it has an advantage that it is able to form by using such as an ordinary light projector if the structure of the jig 12 is well designed.

[0035] Figure 4 shows cross sectional drawing of separation walls that is formed in this invention. Because it is in a shape that the bottom film remain between the ribs, the ribs unified after curing are strongly bonded to the back plate in large area, therefore, the separation walls would not be de-laminated from the back wall when releasing from the mold. Further, because it is a structure that surface of the electrodes is covered with the separation wall material, exhaustion of electrode by sputtering at electric discharge may be prevented. Further, the bottom film takes an role of reflective material that prevents light emission of RGB escaping through the back plate, therefore, brightness is increased.

[0036] Figure 5 shows one example of forming mold that was used in the embodiment of this invention, and it is in a composite structure comprising the thin plate forming mold 6 and the cushion material 5. The reason why the thin plate elastic forming mold 6 is used is to minimize the releasing force by releasing in sequence from an end section by utilizing elastic deformation of the forming mold when releasing from the mold. Further, the cushion material 5 is used for apply uniform pressure without influenced by such as waving of substrate surface. As the material for the forming mold, it is able to use various materials such as rubber and plastics, and ceramics and metal, however, from the reason that it is excellent in durability and dimensional stability, such as metal plate of minimum about 0.3 mm in thickness and maximum about 1 mm, for example, is desirable. Of course it is able to use a forming mold of stiff material, however, it is going to simultaneously release from the mold for entire surface and requires greater releasing force, because deformation of mold is hardly expected. Accordingly, formed separation walls are prone to breakage.

[0037] On the other hand, various materials may be used as the cushion material, and such as rubber and plastics are desirable. The pressure force can be well controlled in this use by adjusting their hardness.

[0038]

[Effect of the invention] As described in the above, it is able to mention as the industrial effect of this invention that emission of waste material is controlled in minimum because it forms separation walls for PDP by using material at necessary minimum amount, therefore, it can be called as an environmentally gentle production method.

[0039] Further, the effect on production method is that because it hardens separation wall material while it is unified with the forming mold, the separation walls after forming have sufficient strength after forming, and because of the used of thin plate elastic forming mold, uniform application of pressure is possible and reduction of releasing force is possible. Therefore, there is no occurrence of de-lamination of the separation wall from the back plate or breakage of the separation wall ribs when releasing from a mold, which means it is secure and high in yield. Further, there also is an advantage that special molding equipment is not necessary because this is a method that does from transfer forming till hardening in a transportation jig.

[Brief explanation of the drawings]

[Figure 1] An explanation drawing showing basic process of this invention.

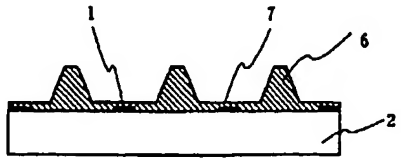
[Figure 2] A process drawing showing the first embodiment example of this invention.

[Figure 3] A process drawing showing the second embodiment example of this invention.

[Figure 4] A drawing showing a cross section of the separation wall of this invention.
[Figure 5] An explanation drawing showing the structure of forming mold that is sued in this invention.
[Figure 6] An explanation drawing showing another production process of backside substrate by previous technology.
[Figure 7] An explanation drawing showing another production process of backside substrate by previous technology.
[Figure 8] An explanation drawing showing another production process of backside substrate by previous technology.
[Explanation of numbers]
1: electrode, 2: back plate, 3: separation wall paste, 4: thin plate elastic mold, 5: cushion material, 6: separation wall rib, 7: bottom film, 8: top plate, 9: substrate positioning and fixing mechanism, 10: bottom plate, 11: hinge, 12: transport molding jig, 13: de-aeration chamber, 14: pressure force, 15: furnace, 16: ultraviolet light, 21: electrode, 22: back plate, 23: glass paste, 24: mask, 25: abrasive material, 26: separation wall rib, 30: polymer film, 31: mold, 40: burying mold

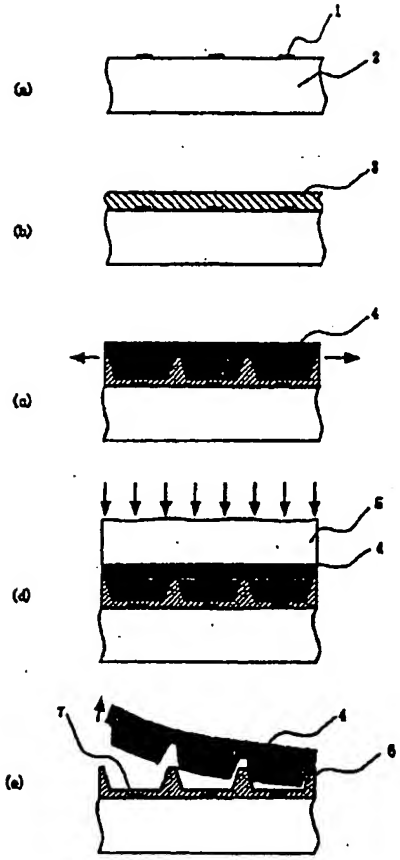
[Figure 4]

Figure 4



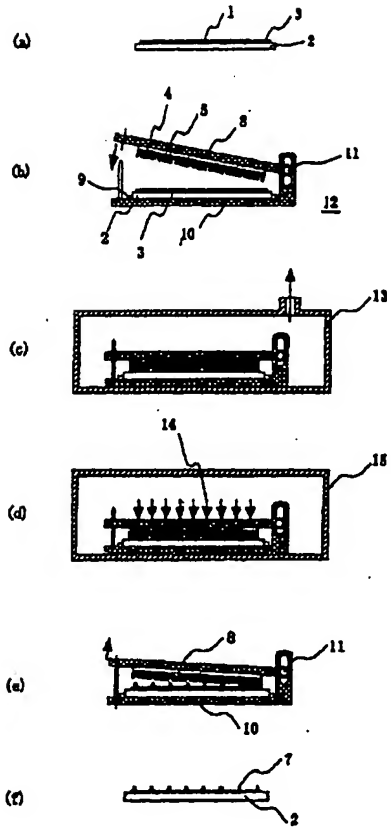
[Figure 1]

Figure 1



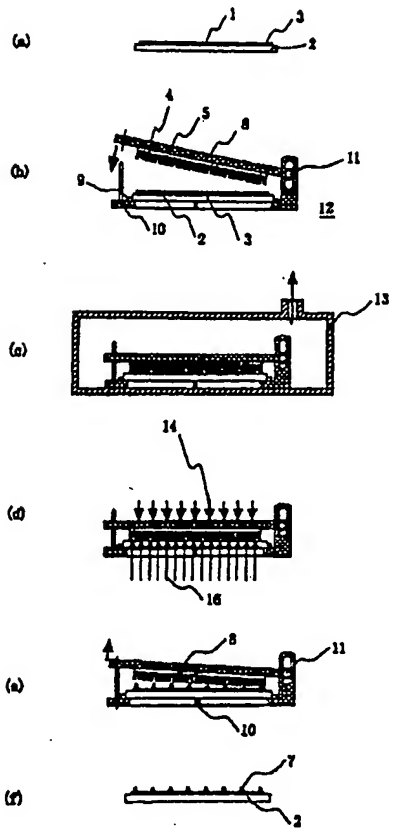
[Figure 2]

Figure 2



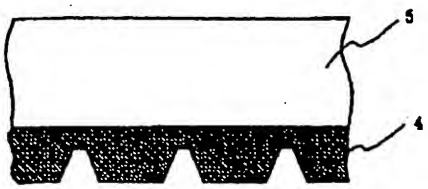
[Figure 3]

Figure 3



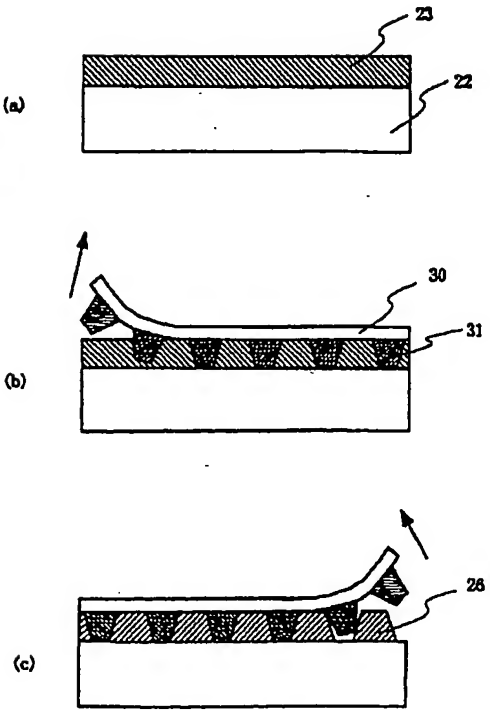
[Figure 5]

Figure 5



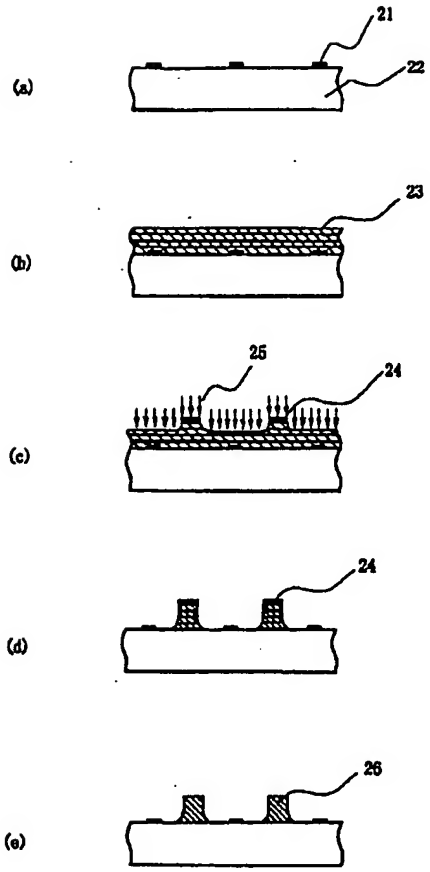
[Figure 7]

Figure 7



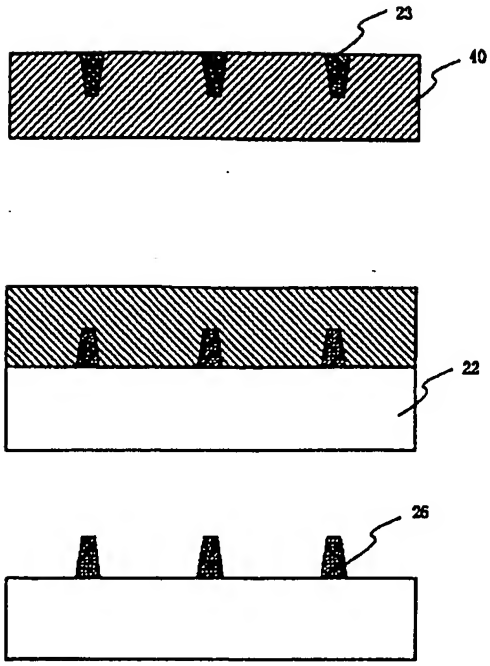
[Figure 6]

Figure 6



[Figure 8]

Figure 8



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